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FR-13168  
VOLUME III  
31 July 1980

**FINAL REPORT**  
**ORBIT TRANSFER VEHICLE**  
**ENGINE STUDY**  
**PROGRAM COSTS**



(NASA-CR-161574) ORBIT TRANSFER VEHICLE  
ENGINE STUDY. VOLUME 3: PROGRAM COSTS  
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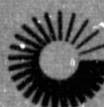
Prepared for  
National Aeronautics and Space Administration  
George C. Marshall Space Flight Center  
Marshall Space Flight Center, Alabama 35812



**PRATT & WHITNEY AIRCRAFT GROUP**

Government Products Division

P. O. Box 2691  
West Palm Beach, Florida 33402



**UNITED  
TECHNOLOGIES®**

FR-13168  
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**SECTION 1.0**

**SUMMARY**

This volume presents Budgetary and Planning Cost Estimates that have been prepared for the Development, Production and Operation and Flight Support phases for each of the engines proposed for OTV propulsion. A general description of the major features of each category engine is presented in Section 2. The Derivative IIA, IIB and IIC engines are derivatives of the RL10A-3-3 engine. The Category IV and Advanced Expander Cycle configurations are completely new engines, but ones which still use the expander cycle. A detailed technical description of the Derivative IIA, IIB and Category IV engines is presented in Volume II of P&WA FR-6011 "Design Study of RL10 Derivatives."

The development program estimates were structured to the preliminary program Work Breakdown Structures (WBS) presented herein as Section 3. Program costs are provided within the applicable WBS elements to Level 4 for each category engine. These program estimates are based on the development program schedules and requirements delineated in the Program Development Plan and the preliminary Design Verification Specifications (DVS) (see Volume II of this report — Section 7.0).

The production program cost estimates assume a first production lot of 50 units produced at a rate of two units per month. Cumulative average unit costs assume a 90% learning capability. A cumulative expected production program cost curve is presented for each category engine. Production program schedules have also been developed from the assumed PFC date and allow 24 mo lead time for procurement of hardware and engine delivery.

The operations and flight support cost estimates are based on 15, 30 and 45 missions per year for the period 1988 through 1999. To satisfy the OTV propulsion system requirements through 1999, a total of 50 production engines were assumed. Estimates for each engine category are presented in terms of total program cost and cost per year.

Estimated funding requirements have been developed for each category and program phase and presented with each detailed cost estimate on the Funding Schedule Data Form C. *All cost estimates and funding data are presented in 1979 dollars.* The assumptions and ground rules for these estimates are summarized in Section 4.



**SECTION 2.0**

**GENERAL DESCRIPTION OF THE ALTERNATIVE BASELINE ENGINES**

**2.1 RL10 DERIVATIVE IIA**

This engine consists of an RL10A3-3 engine with:

- Recontoured, High-Expansion-Ratio, Two-Position Nozzle
- Reoptimized Injector
- Tank Head Idle Mode Capability
- "Zero" NPSH Operation Capability
- Pumped Idle Mode Capability
- Autogenous Pressurization Capability (Fuel and Oxidizer)
- Life: 190 firing/5 hr

**2.2 RL10 DERIVATIVE IIB**

This engine consists of an RL10A3-3 engine with:

- Recontoured, High-Expansion-Ratio, Two-Position Nozzle
- Reoptimized Injector
- Tank Head Idle Mode Capability
- Pumped Idle Mode Capability
- Autogenous Pressurization (Fuel and Oxidizer)
- Life: 190 firings/5 hr

**2.3 RL10 DERIVATIVE IIC**

This engine consists of an RL10A3-3 engine with:

- Recontoured, High-Expansion-Ratio, Two-Position Nozzle
- Autogenous Pressurization (Fuel only)
- Life: 10 firings/1.25 hr

**2.4 RL10 CATEGORY IV ENGINE**

- New High-Performance Expander Cycle Engine (1973 Technology)
- Designed for Orbit Transfer Vehicle Application
- Tank Head Idle Mode Capability
- Pumped Idle Mode Capability
- Two-Position Nozzle
- "Zero" NPSH Operation Capability
- Interchangeable With RL10 Derivative IIA
- Life: 300 firings/10 hours

**2.5 ADVANCED EXPANDER CYCLE ENGINE**

- New High Performance Expander Cycle Engine (1980 Technology)
- Designed for Orbit Transfer Vehicle Application
- Two-Position Nozzle
- Tank Head Idle Mode Capability
- Pumped Idle Mode Capability
- Life: 300 firings/10 hours

**SECTION 3.0**

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- 1.3.5 Follow-On Spares
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- 1.3.7 Consumables

## SECTION 4.0

### COST-ESTIMATING ASSUMPTIONS/GROUND RULES

#### 4.1 GENERAL

1. All cost estimates exclude fee or profit.
2. All estimates are in 1979 dollars.
3. Estimates are based on a 2-shift, 5-day workweek.
4. Propellant cost estimates in all programs are based on the following quotations:
  - $\text{LH}_2$  \$1.94/lb\*
  - $\text{LN}_2$  \$70/ton\*\*
  - $\text{LO}_2$  \$64/ton\*\*
  - $\text{GN}_2$  \$3.25/1000 SCF\*\*
  - $\text{GH}_4$  \$49/1000 SCF\*\*
5. All cost estimates include facilities reactivation and modifications.

\* FOB destination, per July 1979 MSFC Financial Report

\*\* Per 7/1/79 "Air Force Stock Costs"

#### 4.2 DEVELOPMENT

1. All cost estimates are "clean sheet," which exclude consideration of residual GFP material.
2. All off-site testing at Government installations will be at Government expense, over and above the estimated amounts shown herein.
3. Development estimates are for engine development through FFC.
4. Estimates are based on rent-free use of all required Government-owned facilities and equipment.

#### 4.3 PRODUCTION

1. Production delivery requirements will approximate two engines per month.
2. Based on two engines per month, no additional production tooling or STE will be required over those specified for the development program.
3. Costs of parts and labor to incorporate engineering changes are not included in these estimates (to be negotiated separately).

**4.4 OPERATIONS AND FLIGHT SUPPORT**

1. The Operations and Flight Support time period will be from 1988 through 1999.
2. Only one launch site and one vehicle manufacturer site will be used.
3. Support program will consist of a maximum of 10 vehicles, requiring 10 engines plus 3 spare engines.
4. Spare parts will be required to support a minimum of 50 engines.
5. Level 1 and 2 maintenance involving component adjustment/replacement will be performed by NASA or vehicle contractor maintenance personnel at the launch site as well as at the vehicle manufacturer's site. Level 3 maintenance involving engine disassembly and testing will be performed by P&WA assembly and test personnel at the depot (GPD) only.
6. NASA will provide spare parts warehousing at the launch site and at the vehicle manufacturer's site.
7. Training of NASA maintenance personnel will be provided by P&WA.
8. Technical supervision will be provided by P&WA at the launch site and at the vehicle manufacturer's site.
9. Engines will be installed in vehicles at vehicle manufacturer's site.
10. NASA will provide free use of Government facilities such as:
  - Office and maintenance areas at launch site
  - Government vehicles for onsite transportation
  - Ground computers for maintenance analysis.
11. Modification kit installation costs are excluded from these estimates.
12. Estimates include flight support and anomaly resolution effort for a period of 12 yr.

## SECTION 5.0

## DEVELOPMENT PROGRAM COST ESTIMATES

Development program cost estimates were made for each engine category using previous RL10 program cost experience (Table 5-1). A preliminary program plan and schedule was developed for each engine category. Analyses were made of such factors as hardware complexity, sets of hardware required, Bill-of-Material cost, expected weight and engine thrust requirements, mixture ratios, numbers and types of tests, and program duration. These factors were compared and analyzed against similar historical requirements for RL10 development programs. Adjustments were made for differences in configuration, test programs, program duration, and other factors, such as escalation, between the proposed programs and historical programs. Tables 8-1, 8-2 (Derivative IIA), 9-1, 9-2 (Derivative IIB), 10-1, 10-2 (Derivative IIC), 11-1, 11-2 (Category IV), and 12-1, 12-2 (Advanced Expander Cycle Engine) present the various development program cost estimates in detail.

The baseline engine development program estimates were structured in accordance with the preliminary program WBS and presented to WBS Level 4 (see Section 3). These estimates include development efforts through final flight certification (FFC). Figures 8-1 (Derivative IIA), 9-1 (Derivative IIB), 10-1 (Derivative IIC), 11-1 (Category IV), and 12-1 (Advanced Expander Cycle Engine) present the engine development schedules in detail.

TABLE 5-1. DDT&E PROGRAM COST ESTIMATES BY ENGINE CATEGORY

	<i>Derivative IIA</i>	<i>Derivative IIB</i>	<i>Derivative IIC</i>	<i>Category IV</i>	<i>Advanced Expander Cycle</i>
Development Through FFC	\$83.90	\$67.69	\$17.79	\$135.93	\$217.0
Propellants	16.04	11.23	2.76	20.65	25.8
Total	\$99.94	\$78.92	\$20.55	\$156.58	\$242.8

Note: All costs in millions of 1979 dollars and exclude fee.

## SECTION 6.0

## PRODUCTION PROGRAM COST ESTIMATES

The production program cost estimates were developed for each engine category using previous RL10 production program experience (Table 6-1). The first production unit cost includes the cost of fabrication and assembly, acceptance testing and preparation for shipment. For the production rate assumed (two engines per month) the development program tooling and special test equipment can be used, and therefore, no new production tooling will be required.

Production engine acceptance testing includes preliminary tests and final acceptance tests similar to that used to determine acceptability of current production RL10A-3-3 engines. The derivative production engine unit cost estimates are based on the current RL10A-3-3 engine costs, with the major adjustments derived from parts list differences and degree of acceptance testing difficulty.

Estimated costs are presented for the 1st unit, the 50th unit, and cumulative average of 50 units. These estimates assume a 90% learning capability. The total Production Program costs for each engine category are presented in Figures 8-2 (Derivative IIA), 9-2 (Derivative IIB), 10-2 (Derivative IIC), 11-2 (Category IV) and 12-2 (Advanced Expander Cycle Engine), and detail cost statistics are presented in cost tables 8-3, 8-4 (Derivative IIA), 9-3, 9-4 (Derivative IIB), 10-3, 10-4 (Derivative IIC), 11-3, 11-4 (Category IV), and 12-3, 12-4 (Advanced Expander Cycle).

TABLE 6-1. PRODUCTION COST ESTIMATES BY ENGINE CATEGORY

	Derivative IIA	Derivative IIB	Derivative IIC	Category IV	Advanced Expander Cycle
First Unit Cost	\$ 1.56	\$ 1.50	\$ 1.35	\$ 1.76	\$ 1.87
50th Unit Cost	\$ 0.86	\$ 0.83	\$ 0.74	\$ 0.97	\$ 1.03
CUM AVG 50 Units	\$ 1.00	\$ 0.96	\$ 0.87	\$ 1.13	\$ 1.20
50 Unit Production Program Cost					
Without Propellants	\$50.3	\$48.3	\$43.5	\$56.6	\$60.0
Propellants	\$ 3.5	\$ 3.5	\$ 3.5	\$ 3.5	\$ 3.5
50 Unit Production Cost With Propellants	\$53.8	\$51.8	\$47.0	\$60.1	\$63.5

Note: All costs in millions of 1979 dollars and exclude fee



## SECTION 7.0

## OPERATIONS AND FLIGHT SUPPORT COST ESTIMATES

Operations and flight support cost estimates were developed for each engine category. These estimates use data from the preliminary requirements defined, existing support services at P&WA, and our experience in supporting commercial and military aircraft and launch vehicle programs. This operations and flight support program is defined for the period 1988 through 1999 and is based on a preliminary plan to tailor the existing P&WA support organizations to OTV needs.

Table 7-1 presents a summary of the operations and flight support program costs for each engine category, for 15, 30 and 45 missions per year. Detail cost estimates for each engine category are presented in cost tables 8-5, 8-6 (Derivative IIA), 9-5, 9-6 (Derivative IIB), 10-5, 10-6 (Derivative IIC), 11-5, 11-6 (Category IV) and 12-5, 12-6 (Advanced Expander Cycle).

TABLE 7-1. OPERATIONS AND FLIGHT SUPPORT COST  
ESTIMATES BY ENGINE CATEGORY

<i>Flights/Year</i>	<i>Derivative IIA</i>	<i>Derivative IIB</i>	<i>Derivative IIC</i>	<i>Category IV</i>	<i>Advanced Expander Cycle</i>
15	78.2	68.9	72.2	86.1	86.1
30	86.0	76.5	-	94.5	94.5
45	102.7	93.0	-	103.5	103.5

## Notes:

1. 12-year operational programs
2. Costs shown include propellants (estimated to be \$10.5 million for each program)
3. Costs are in millions of 1979 dollars and exclude fee.

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## SECTION 8.0

### RL10 DERIVATIVE IIA ENGINE PROGRAM COSTS

COST TABLE 8-1. RL10 DERIVATIVE IIA NONRECURRING (DDT&E)

Study Title:	OTV Engine Study	Cost Data Form --- A(1)	Date:	9/21/79		
Contract No.:	NAS8-33444	Non-Recurring (EDT&E)	Page:	1 of 1		
Identification						Spread
Number	WBS Identification	WBS Level	Expected Cost	T <sub>d</sub>	T <sub>e</sub>	Function
1.1	DDT&E	2	99.94			
1.1.1	Turbomachinery	3	6.63			
1.1.1.1	Main Fuel Pump	4	1.66			
1.1.1.2	Main Oxidizer Pump	4	2.32			
1.1.1.3	Fuel Boost Pump	4	0.0			
1.1.1.4	Oxidizer Boost Pump	4	0.0			
1.1.1.5	Assembly and Checkout	4	2.65			
1.1.2	Main Combustor Chamber	3	9.58			
1.1.2.1	Injector	4	2.38			
1.1.2.2	Chamber	4	2.40			
1.1.2.3	Upper Nozzle (Fixed)	4	1.44			
1.1.2.4	Igniter	4	0.96			
1.1.2.5	Gimbal Assembly	4	0.48			
1.1.2.6	Assembly and Checkout	4	1.92			
1.1.3	Preburner/Gas Generator	3	0.0			
1.1.4	Nozzle Assembly	3	8.66			
1.1.4.1	Lower Nozzle (Extendable)	4	5.19			
1.1.4.2	Extension/Retraction Mechanism	4	0.87			
1.1.4.3	Assembly and Checkout	4	2.60			
1.1.5	Controls	3	4.37			
1.1.5.1	Engine Controller and Electrical Harness	4	1.74			
1.1.5.2	Control Valves	4	1.31			
1.1.5.3	Instrumentation and Electrical Harness	4	0.66			
1.1.5.4	Assembly and Checkout	4	0.66			
1.1.6	Pressurization	3	0.39			
1.1.6.1	Heat Exchanger	4	0.27			
1.1.6.2	Assembly and Checkout	4	0.12			
1.1.7	Propellant Systems	3	0.10			
1.1.7.1	Feed, Fill, Vent, Abort Dump, Drain	4	0.08			
1.1.7.2	Assembly and Checkout	4	0.02			
1.1.8	Initial Tooling	3	2.07			
1.1.9	Ground Support Equipment	3	0.76			
1.1.9.1	Handling and Protective Equipment	4	0.08			
1.1.9.2	Checkout and Maintenance Equipment	4	0.45			
1.1.9.3	Assembly and Checkout	4	0.23			
1.1.10	Test	3	21.64			
1.1.10.1	Development Testing	4	8.12			
1.1.10.2	PFC Testing	4	8.12			
1.1.10.3	FFC Testing	4	5.40			
1.1.11	System Engineering and Integration	3	12.09			
1.1.11.1	Integration of DDT&E Activities	4	4.02			
1.1.11.2	Engine Assembly and Checkout	4	3.43			
1.1.11.3	Engine/Vehicle Interface	4	4.64			
1.1.12	Project Management	3	2.83			
1.1.13	Facilities and STE	3	14.78			
1.1.14	Consumables	3	16.04			

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**COST TABLE 8-2. RL10 DERIVATIVE IIA DDT&E FUNDING SCHEDULE**

Study Title:	OTV Engine Study	Funding Schedule Data Form C					Date:	9/21/79
Contract No.:	NAS8-33444	Non-Recurring (DDT&E)					Page:	1 of 1
Project WBS Items		FY 1	FY 2	FY 3	FY 4	FY 5	FY 6	
Main Engine		8.7	12.4	20.4	27.2	24.8	6.4	
DDT&E (1.1)								

Note: All costs in millions of 1979 dollars, include propellants, exclude fee

**COST TABLE 8-3. RL10 DERIVATIVE IIA RECURRING (PRODUCTION)**

Study Title:	OTV Engine Study	Cost Data Form -- A(2)					Date:	9/21/79
Contract No.:	NAS8-33444	Recurring (Production)					Page:	1 of 1
Identification Number	WBS Identification	WBS Level	No. of Units	First Unit Cost	Expected Cost	Spread Function	Learn Index	
1.2	Production	2	50	1.56	53.84		90%	
1.2.1	Main Engine	3			43.76			
1.2.1.1	Turbomachinery	4			12.53			
1.2.1.2	Combustion Devices	4			12.75			
1.2.1.3	Controls	4			12.32			
1.2.1.4	Pressurization	4			3.40			
1.2.1.5	Propellant Systems	4			1.49			
1.2.1.6	Engine Assembly	4			1.27			
1.2.2	Initial Spares	3			0			
1.2.3	Facility Maintenance	3			2.00			
1.2.3.1	Manufacturing & Test Facil.	4			0			
1.2.3.2	Sustaining Tooling	4			2.00			
1.2.3.3	GSE	4			0			
1.2.4	Sustaining Engineering	3			4.12			
1.2.5	Project Management	3			0.46			
1.2.6	Consumables	3			3.50			

Note: All costs are in millions of 1979 dollars excluding fee

**COST TABLE 8-4. RL10 DERIVATIVE IIA PRODUCTION FUNDING SCHEDULE**

Study Title:	OTV Engine Study	Funding Schedule Data Form C					Date:	9/21/79
Contract No.:	NAS8-33444	Recurring (Production)					Page:	1 of 1
Project WBS Items		FY 1	FY 2	FY 3	FY 4	FY 5		
Main Engine		4.9	10.2	15.9	13.7	9.1		
Production (1.2)								

Note: All costs in millions of 1979 dollars, include propellants, exclude fee

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**COST TABLE 8-5a. RL10 DERIVATIVE IIA RECURRING (OPERATIONS)  
15 MISSIONS PER YEAR**

Study Title: OTV Engine Study		Cost Data Form -- A(3)		Date: 9/21/79
Contract No.: NAS8-33444		Recurring (Operations)		Page: 1 of 1
WBS Identification	Identification Number	WBS Level	No. of Units	Expect Cost
1.3	Operations	2	180	78.18
1.3.1	In-plant Support	3		24.97
1.3.2	Field Support	3		22.55
1.3.2.1	Launch Support	4		6.19
1.3.2.2	Flight Support	4		0.38
1.3.2.3	Refurbishment and Maintenance	4		9.79
1.3.2.4	Checkout	4		6.19
1.3.3	Major Engine Overhaul	3		2.92
1.3.4	Facility Maintenance	3		1.35
1.3.5	Follow-on Spares	3		4.76
1.3.6	Project Management	3		11.15
1.3.7	Consumables	3		10.48

Note: All costs are in millions of 1979 dollars excluding fee.

**COST TABLE 8-5b. RL10 DERIVATIVE IIA RECURRING (OPERATIONS)  
30 MISSIONS PER YEAR**

Study Title: OTV Engine Study		Cost Data Form -- A(3)		Date: 9/21/79
Contract No.: NAS8-33444		Recurring (Operations)		Page: 1 of 1
WBS Identification	Identification Number	WBS Level	No. of Units	Expect Cost
1.3	Operations	2	360	86.00
1.3.1	In-plant Support	3		25.64
1.3.2	Field Support	3		26.30
1.3.2.1	Launch Support	4		6.70
1.3.2.2	Flight Support	4		0.38
1.3.2.3	Refurbishment and Maintenance	4		12.52
1.3.2.4	Checkout	4		6.70
1.3.3	Major Engine Overhaul	3		4.52
1.3.4	Facility Maintenance	3		1.35
1.3.5	Follow-on Spares	3		6.58
1.3.6	Project Management	3		11.15
1.3.7	Consumables	3		10.48

Note: All costs are in millions of 1979 dollars excluding fee.

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## COST TABLE 8-5c. RL10 DERIVATIVE IIA RECURRING (OPERATIONS) 45 MISSIONS PER YEAR

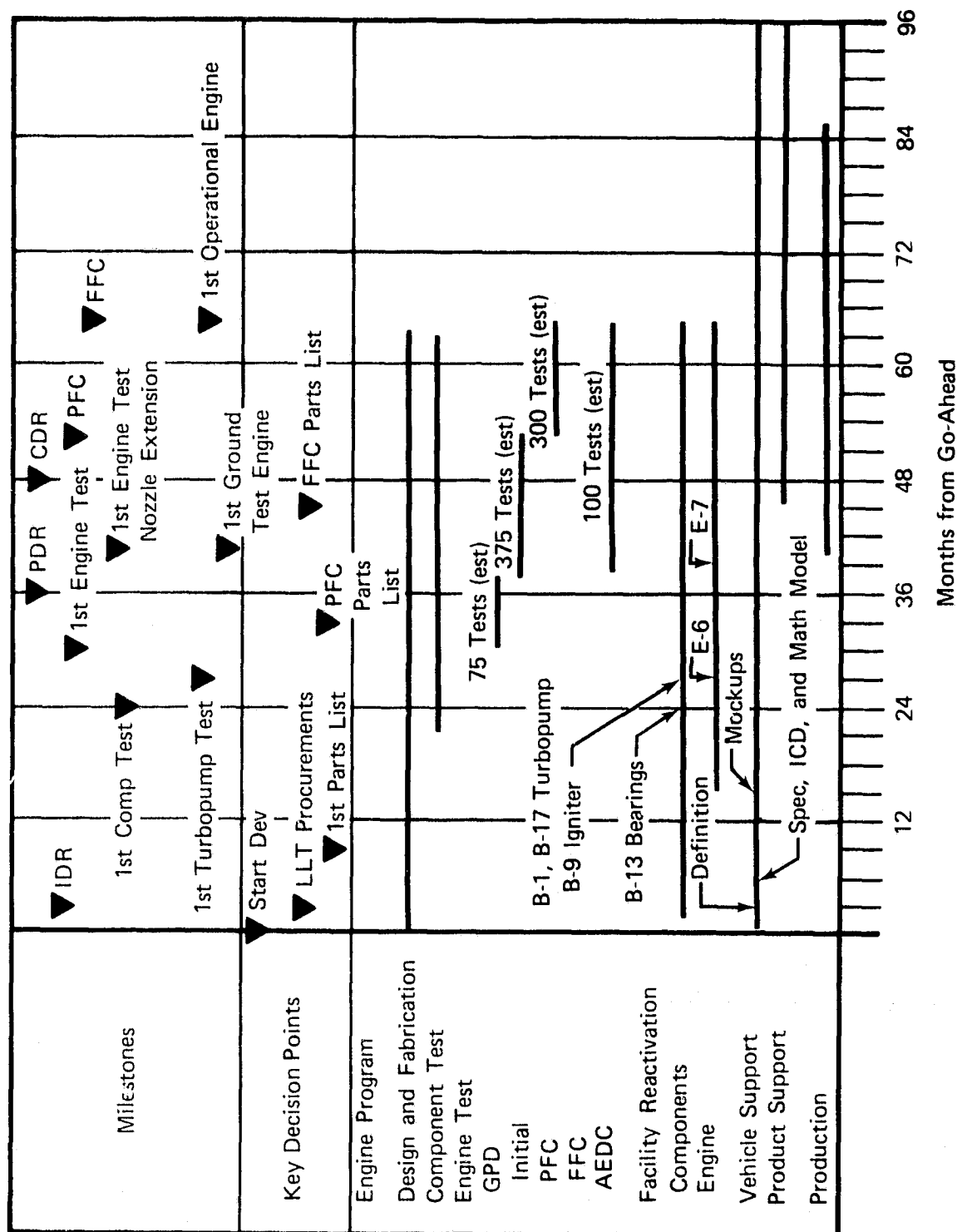
Study Title:	OTV Engine Study	Cost Data Form	A(3)	Date:	9/21/79
Contract No.:	NAS8-33444	Recurring (Operations)		Page:	1 of 1
WBS Identification	Identification Number	WBS Level	No. of Units	Expect Cost	
1.3	Operations	2	540	102.69	
1.3.1	In-plant Support	3		28.04	
1.3.2	Field Support	3		37.04	
1.3.2.1	Launch Support	4		8.51	
1.3.2.2	Flight Support	4		0.38	
1.3.2.3	Refurbishment and Maintenance	4		19.64	
1.3.2.4	Checkout	4		8.51	
1.3.3	Major Engine Overhaul	3		6.13	
1.3.4	Facility Maintenance	3		1.35	
1.3.5	Follow-on Spares	3		8.50	
1.3.6	Project Management	3		11.15	
1.3.7	Consumables	3		10.48	

Note: All costs are in millions of 1979 dollars excluding fee.

## COST TABLE 8-6. RL10 DERIVATIVE IIA OPERATIONS FUNDING SCHEDULE

Study Title:	OTV Engine Study		Funding Schedule Data Form C				Date:	9/21/79
Contract No.:	NAS8-33444		Recurring (Operations)				Page:	1 of 1
Project WBS Items	FY 1	FY 2	FY 3	FY 4	FY 5	FY 6	FY 7	
Main Engine Operations (1.3)								
Flights per year								
15	13.3	12.5	10.9	10.1	8.1	5.9	2.9	
30	22.4	18.1	14.6	3.5	3.5	3.5	3.4	
45	30.8	20.5	11.6	4.5	4.5	4.4	4.4	
	FY 8	FY 9	FY 10	FY 11	FY 12			
15	2.9	2.9	2.9	2.9	2.9			
30	3.4	3.4	3.4	3.4	3.4			
45	4.4	4.4	4.4	4.4	4.4			

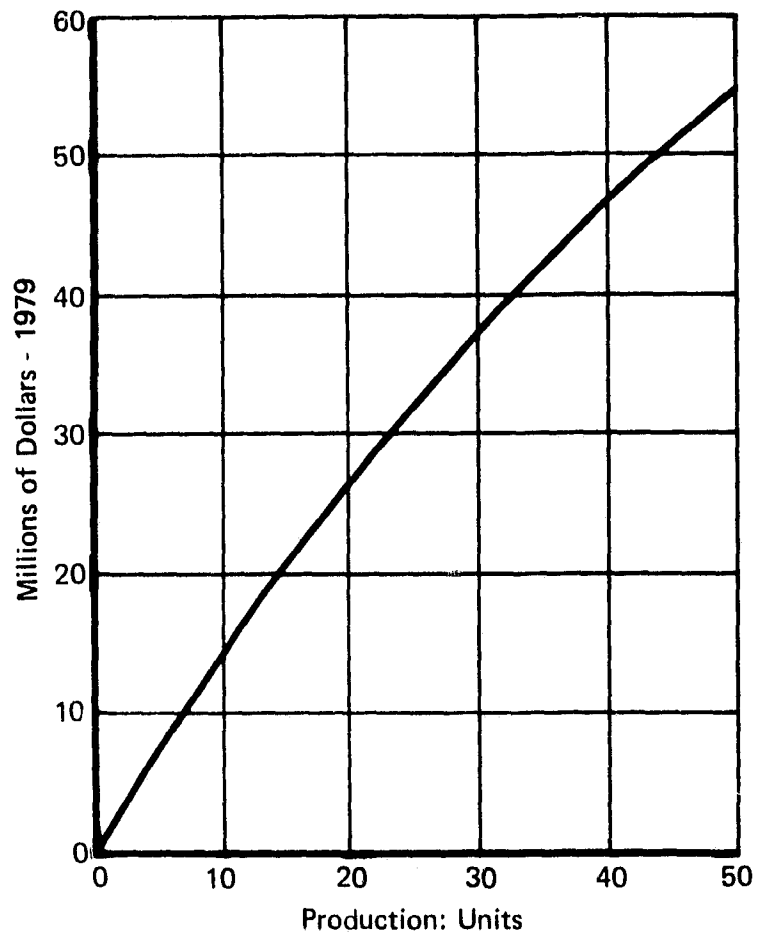
Note: All costs in millions of 1979 dollars, include propellants cost, but excludes fee



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*Figure 8-2. RL10 Derivative IIA Engine Production Cumulative Cost Curve (Costs Include Propellants and Exclude Fee)*

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## SECTION 9.0

### RL10 DERIVATIVE IIB ENGINE PROGRAM COSTS

COST TABLE 9-1. RL10 DERIVATIVE IIB NONRECURRING (DDT&E)

Study Title:	OTV Engine Study	Cost Data Form -- A(1)	Date:	9/21/79
Contract No.:	NAS8-33444		Page:	1 of 1

Identification Number	WBS Identification	WBS Level	Expected Cost	T <sub>d</sub>	T <sub>s</sub>	Spread Function
1.1	DDT&E	2	78.92			
1.1.1	Turbomachinery	3	3.06			
1.1.1.1	Main Fuel Pump	4	1.00			
1.1.1.2	Main Oxidizer Pump	4	0.45			
1.1.1.3	Fuel Boost Pump	4	0.0			
1.1.1.4	Oxidizer Boost Pump	4	0.0			
1.1.1.5	Assembly and Checkout	4	1.61			
1.1.2	Main Combustor Chamber	3	8.40			
1.1.2.1	Injector	4	2.10			
1.1.2.2	Chamber	4	2.18			
1.1.2.3	Upper Nozzle (Fixed)	4	1.26			
1.1.2.4	Igniter	4	0.84			
1.1.2.5	Gimbal Assembly	4	0.42			
1.1.2.6	Assembly and Checkout	4	1.60			
1.1.3	Preburner/Gas Generator	3	0.0			
1.1.4	Nozzle Assembly	3	9.00			
1.1.4.1	Lower Nozzle (Extendable)	4	5.40			
1.1.4.2	Extension/Retraction Mechanism	4	0.90			
1.1.4.3	Assembly and Checkout	4	2.70			
1.1.5	Controls	3	3.92			
1.1.5.1	Engine Controller and Electrical Harness	4	1.57			
1.1.5.2	Control Valves	4	1.17			
1.1.5.3	Instrumentation and Electrical Harness	4	0.59			
1.1.5.4	Assembly and Checkout	4	0.59			
1.1.6	Pressurization	3	0.34			
1.1.6.1	Heat Exchanger	4	0.24			
1.1.6.2	Assembly and Checkout	4	0.10			
1.1.7	Propellant Systems	3	0.09			
1.1.7.1	Feed, Fill, Vent, Abort Dump, Drain	4	0.07			
1.1.7.2	Assembly and Checkout	4	0.02			
1.1.8	Initial Tooling	3	1.82			
1.1.9	Ground Support Equipment	3	0.62			
1.1.9.1	Handling and Protective Equipment	4	0.06			
1.1.9.2	Checkout and Maintenance Equipment	4	0.38			
1.1.9.3	Assembly and Checkout	4	0.18			
1.1.10	Test	3	18.85			
1.1.10.1	Development Testing	4	7.07			
1.1.10.2	PFC Testing	4	5.89			
1.1.10.3	FFC Testing	4	5.89			
1.1.11	System Engineering and Integration	3	10.76			
1.1.11.1	Integration of DDT&E Activities	4	3.60			
1.1.11.2	Engine Assembly and Checkout	4	3.06			
1.1.11.3	Engine/Vehicle Interface	4	4.10			
1.1.12	Project Management	3	2.23			
1.1.13	Facilities and STE	3	8.60			
1.1.14	Consumables	3	11.23			



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**COST TABLE 9-2. RL10 DERIVATIVE IIB DDT&E FUNDING SCHEDULE**

Study Title:	OTV Engine Study		Funding Schedule Data Form C		Date:	9/21/79
Contract No.:	NAS8-33444		Non-Recurring (DDT&E)		Page:	1 of 1
Project WBS Items	FY 1	FY 2	FY 3	FY 4	FY 5	
Main Engine	7.1	11.4	18.9	24.3	17.2	
DDT&E (1.1)						

Note: All costs in millions of 1979 dollars, include propellants cost, exclude fee

**COST TABLE 9-3. RL10 DERIVATIVE IIB RECURRING (PRODUCTION)**

Study Title:	OTV Engine Study	Cost Data Form — A(2)				Date:	9/21/79
Contract No.:	NAS8-33444	Recurring (Production)				Page:	1 of 1
Identification Number	WBS Identification	WBS Level	No. of Units	First Unit Cost	Expected Cost	Spread Function	Learn Index
1.2	Production	2	50	1.50	51.80		90%
1.2.1	Main Engine	3			41.97		
1.2.1.1	Turbomachinery	4			12.04		
1.2.1.2	Combustion Devices	4			12.21		
1.2.1.3	Controls	4			11.83		
1.2.1.4	Pressurization	4			3.26		
1.2.1.5	Propellant System	4			1.43		
1.2.1.6	Engine Assembly	4			1.20		
1.2.2	Initial Spares	3			0.0		
1.2.3	Facility Maintenance	3			1.93		
1.2.3.1	Manufacturing & Test Facil.	4			0.0		
1.2.3.2	Sustaining Tooling	4			1.93		
1.2.3.3	GSE	4			0.0		
1.2.4	Sustaining Engineering	3			3.96		
1.2.5	Project Management	3			0.44		
1.2.6	Consumables	3			3.50		

Note: All costs are in millions of 1979 dollars excluding fee

**COST TABLE 9-4. RL10 DERIVATIVE IIB PRODUCTION FUNDING SCHEDULE**

Study Title:	OTV Engine Study		Funding Schedule Data Form C		Date:	9/21/79
Contract No.:	NAS8-33444		Recurring (Production)		Page:	1 of 1
Project WBS Items	FY 1	FY 2	FY 3	FY 4	FY 5	
Main Engine	4.7	9.8	15.3	13.2	8.8	
Production (1.2)						

Note: All costs in millions of 1979 dollars, include propellants, exclude fee

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**COST TABLE 9-5a. RL10 DERIVATIVE IIB RECURRING (OPERATIONS)  
15 MISSIONS PER YEAR**

Study Title:	OTV Engine Study	Cost Data Form — A(3)	Date:	9/21/79
Contract No.:	NAS8-33444	Recurring (Operations)	Page:	1 of 1
WBS Identification	Identification Number	WBS Level	No. of Units	Expect Cost
1.3	Operations	2	180	68.90
1.3.1	In-plant Support	3		20.48
1.3.2	Field Support	3		20.59
1.3.2.1	Launch Support	4		5.29
1.3.2.2	Flight Support	4		0.29
1.3.2.3	Refurbishment and Maintenance	4		9.72
1.3.2.4	Checkout	4		5.29
1.3.3	Major Engine Overhaul	3		2.81
1.3.4	Facility Maintenance	3		1.44
1.3.5	Follow-on Spares	3		4.56
1.3.6	Project Management	3		8.54
1.3.7	Consumables	3		10.48

Note: All costs are in millions of 1979 dollars excluding fee.

**COST TABLE 9-5b. RL10 DERIVATIVE IIB RECURRING (OPERATIONS)  
30 MISSIONS PER YEAR**

Study Title:	OTV Engine Study	Cost Data Form — A(3)	Date:	9/21/79
Contract No.:	NAS8-33444	Recurring (Operations)	Page:	1 of 1
WBS Identification	Identification Number	WBS Level	No. of Units	Expect Cost
1.3	Operations	2	360	76.50
1.3.1	In-plant Support	3		21.15
1.3.2	Field Support	3		24.30
1.3.2.1	Launch Support	4		5.80
1.3.2.2	Flight Support	4		0.29
1.3.2.3	Refurbishment and Maintenance	4		12.41
1.3.2.4	Checkout	4		5.80
1.3.3	Major Engine Overhaul	3		4.27
1.3.4	Facility Maintenance	3		1.44
1.3.5	Follow-on Spares	3		6.32
1.3.6	Project Management	3		8.54
1.3.7	Consumables	3		10.48

Note: All costs are in millions of 1979 dollars excluding fee.

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**COST TABLE 9-5c. RL10 DERIVATIVE IIB RECURRING (OPERATIONS)  
45 MISSIONS PER YEAR**

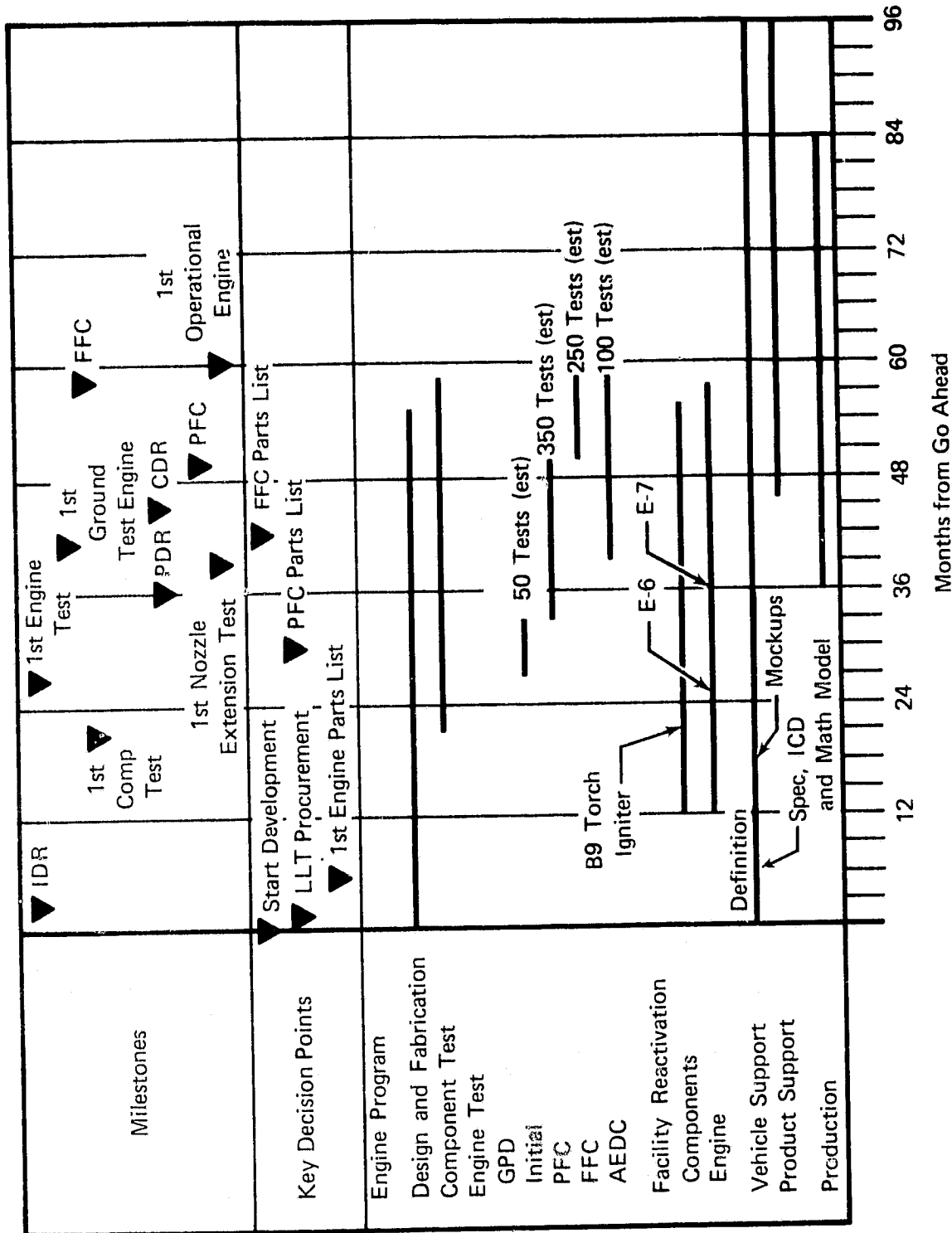
Study Title:	OTV Engine Study	Cost Data Form -- A(3)	Date:	9/21/79
Contract No.:	NAS8-33444	Recurring (Operations)	Page:	1 of 1
WBS Identification	Identification Number	WBS Level	No. of Units	Expect Cost
1.3	Operations	2	540	92.99
1.3.1	In-plant Support	3		23.54
1.3.2	Field Support	3		34.98
1.3.2.1	Launch Support	4		7.61
1.3.2.2	Flight Support	4		0.29
1.3.2.3	Refurbishment and Maintenance	4		19.47
1.3.2.4	Checkout	4		7.61
1.3.3	Major Engine Overhaul	3		5.88
1.3.4	Facility Maintenance	3		1.44
1.3.5	Follow-on Spares	3		8.13
1.3.6	Project Management	3		8.54
1.3.7	Consumables	3		10.48

Note: All costs are in millions of 1979 dollars excluding fee.

**COST TABLE 9-6. RL10 DERIVATIVE IIB OPERATIONS FUNDING SCHEDULE**

Study Title:	OTV Engine Study		Funding Schedule Data Form C			Date:	9/21/79
Contract No.:	NAS8-33444		Recurring (Operations)			Page:	1 of 1
Project WBS Items	FY 1	FY 2	FY 3	FY 4	FY 5	FY 6	FY 7
Main Engine							
Operations (1.3)							
Flights per year							
15	11.7	11.1	9.6	9.0	7.0	5.2	2.6
30	19.9	16.0	13.0	3.1	3.1	3.1	3.1
45	27.9	18.6	10.5	4.0	4.0	4.0	4.0
	FY 8	FY 9	FY 10	FY 11	FY 12		
15	2.6	2.6	2.5	2.5	2.5		
30	3.1	3.1	3.0	3.0	3.0		
45	4.0	4.0	4.0	4.0	4.0		

Note: All costs in millions of 1979 dollars, include propellants cost, exclude fee

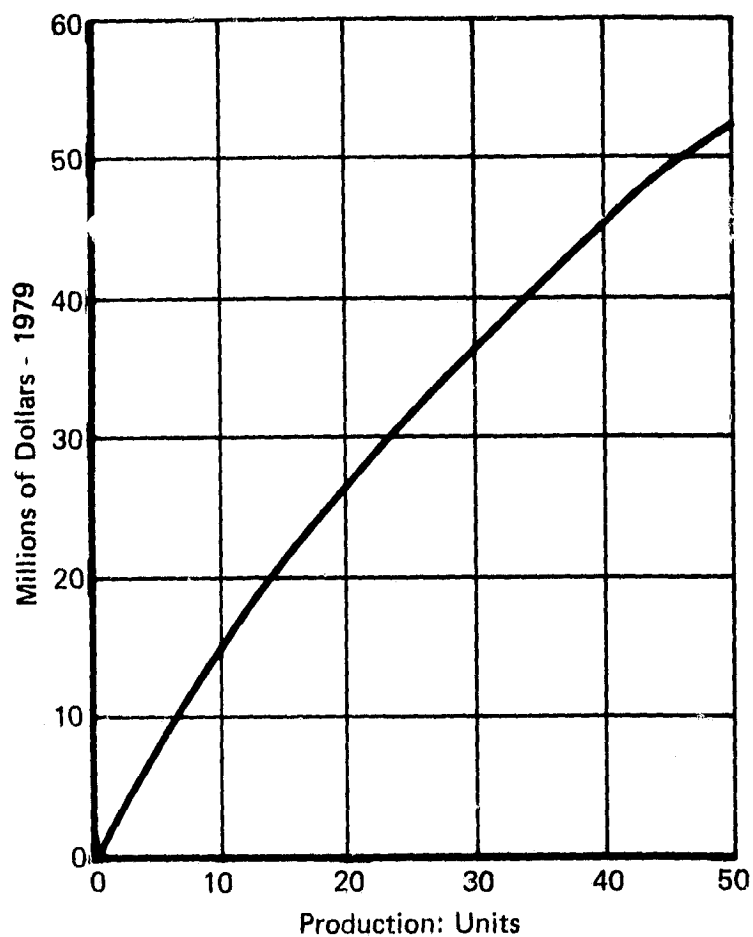


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Figure 9-1. RL10 Derivative IIB Development Schedule and Major Program Milestones

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*Figure 9-2. RL10 Derivative IIB Engine Production  
Cumulative Cost Curve (Costs Include Propellants  
and Exclude Fee)*

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## SECTION 10.0

### RL10 DERIVATIVE IIC ENGINE PROGRAM COSTS

COST TABLE 10-1. RL10 DERIVATIVE IIC NONRECURRING (DDT&E)

Study Title:	OTV Engine Study	Cost Data Form -- A(1)	Date:	9/21/79		
Contract No.:	NAS8-33444		Page:	1 of 1		
Identification Number	WBS Identification	WBS Level	Expected Cost	T <sub>d</sub>	T <sub>s</sub>	Spread Function
1.1	DDT&E	2	20.55			
1.1.1	Turbomachinery	3	1.15			
1.1.1.1	Main Fuel Pump	4	0.70			
1.1.1.2	Main Oxidizer Pump	4	0.30			
1.1.1.3	Fuel Boost Pump	4	0.0			
1.1.1.4	Oxidizer Boost Pump	4	0.0			
1.1.1.5	Assembly and Checkout	4	0.15			
1.1.2	Main Combustor Chamber	3	2.92			
1.1.2.1	Injector	4	0.73			
1.1.2.2	Chamber	4	0.73			
1.1.2.3	Upper Nozzle (Fixed)	4	0.44			
1.1.2.4	Igniter	4	0.29			
1.1.2.5	Gimbal Assembly	4	0.15			
1.1.2.6	Assembly and Checkout	4	0.58			
1.1.3	Preburner/Gas Generator	3	0.0			
1.1.4	Nozzle Assembly	3	3.14			
1.1.4.1	Lower Nozzle (Extendable)	4	1.89			
1.1.4.2	Extension/Retraction Mechanism	4	0.31			
1.1.4.3	Assembly and Checkout	4	0.94			
1.1.5	Controls	3	1.86			
1.1.5.1	Engine Controller and Electrical Harness	4	1.00			
1.1.5.2	Control Valves	4	0.25			
1.1.5.3	Instrumentation and Electrical Harness	4	0.25			
1.1.5.4	Assembly and Checkout	4	0.36			
1.1.6	Pressurization	3	0.0			
1.1.6.1	Heat Exchanger	4	0.0			
1.1.6.2	Assembly and Checkout	4	0.0			
1.1.7	Propellant Systems	3	0.09			
1.1.7.1	Feed, Fill, Vent, Abort Dump, Drain	4	0.07			
1.1.7.2	Assembly and Checkout	4	0.02			
1.1.8	Initial Tooling	3	0.75			
1.1.9	Ground Support Equipment	3	0.43			
1.1.9.1	Handling and Protective Equipment	4	0.06			
1.1.9.2	Checkout and Maintenance Equipment	4	0.28			
1.1.9.3	Assembly and Checkout	4	0.09			
1.1.10	Test	3	3.05			
1.1.10.1	Development Testing	4	2.46			
1.1.10.2	PFC Testing	4	0.0			
1.1.10.3	FFC Testing	4	0.59			
1.1.11	System Engineering and Integration	3	2.25			
1.1.11.1	Integration of DDT&E Activities	4	0.74			
1.1.11.2	Engine Assembly and Checkout	4	0.63			
1.1.11.3	Engine/Vehicle Interface	4	0.88			
1.1.12	Project Management	3	1.75			
1.1.13	Facilities and STE	3	0.40			
1.1.14	Consumables	3	2.76			

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**COST TABLE 10-2. RL10 DERIVATIVE IIC DDT&E FUNDING SCHEDULE**

Study Title:	<u>OTV Engine Study</u>	<u>Funding Schedule Data Form C</u>			Date:	<u>9/21/79</u>
Contract No.:	<u>NAS8-33444</u>	<u>Non-Recurring (DDT&amp;E)</u>			Page:	<u>1 of 1</u>
<i>Project WBS Items</i>		<i>FY 1</i>	<i>FY 2</i>	<i>FY 3</i>	<i>FY 4</i>	
Main Engine DDT&E (1.1)		4.5	5.3	10.0	0.8	

Note: All costs in millions of 1979 dollars, include propellants cost, exclude fee

**COST TABLE 10-3. RL10 DERIVATIVE IIC RECURRING (PRODUCTION)**

Study Title:	<u>OTV Engine Study</u>	<u>Cost Data Form — A(2)</u>				Date:	<u>9/21/79</u>
Contract No.:	<u>NAS8-33444</u>	<u>Recurring (Production)</u>				Page:	<u>1 of 1</u>
<i>Identification Number</i>	<i>WBS Identification</i>	<i>WBS Level</i>	<i>No. of Units</i>	<i>First Unit Cost</i>	<i>Expected Cost</i>	<i>Spread Function</i>	<i>Learn Index</i>
1.2	Production	2	50	1.35	47.00		90%
1.2.1	Main Engine	3			37.80		
1.2.1.1	Turbomachinery	4			10.83		
1.2.1.2	Combustion Devices	4			11.01		
1.2.1.3	Controls	4			10.65		
1.2.1.4	Pressurization	4			2.95		
1.2.1.5	Propellant Systems	4			1.28		
1.2.1.6	Engine Assembly	4			1.08		
1.2.2	Initial Spares	3			0.0		
1.2.3	Facility Maintenance	3			1.74		
1.2.3.1	Manufacturing & Test Facil.	4			0.0		
1.2.3.2	Sustaining Tooling	4			1.74		
1.2.3.3	GSE	4			0.0		
1.2.4	Sustaining Engineering	3			3.56		
1.2.5	Project Management	3			0.40		
1.2.6	Consumables	3			3.50		

Note: All costs are in millions of 1979 dollars excluding fee

**COST TABLE 10-4. RL10 DERIVATIVE IIC PRODUCTION FUNDING SCHEDULE**

Study Title:	<u>OTV Engine Study</u>	<u>Funding Schedule Data Form C</u>			Date:	<u>9/21/79</u>
Contract No.:	<u>NAS8-33444</u>	<u>Recurring (Production)</u>			Page:	<u>1 of 1</u>
<i>Project WBS Items</i>		<i>FY 1</i>	<i>FY 2</i>	<i>FY 3</i>	<i>FY 4</i>	<i>FY 5</i>
Main Engine Production (1.2)		4.2	8.8	14.0	12.0	8.0

Note: All costs in millions of 1979 dollars include propellants, exclude fee

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**COST TABLE 10-5. RL10 DERIVATIVE IIC RECURRING (OPERATIONS)  
15 MISSIONS PER YEAR**

Study Title:	OTV Engine Study	Cost Data Form — A(3)	Date:	9/21/79
Contract No.:	NAS8-33444	Recurring (Operations)	Page:	1 of 1
WBS Identification	Identification Number	WBS Level	No. of Units	Expect Cost
1.3	Operations	2	180	72.17
1.3.1	In-plant Support	3		20.45
1.3.2	Field Support	3		20.63
1.3.2.1	Launch Support	4		5.29
1.3.2.2	Flight Support	4		0.29
1.3.2.3	Refurbishment and Maintenance	4		9.76
1.3.2.4	Checkout	4		5.29
1.3.3	Major Engine Overhaul	3		2.89
1.3.4	Facility Maintenance	3		1.43
1.3.5	Follow-on Spares	3		7.76
1.3.6	Project Management	3		8.53
1.3.7	Consumables	3		10.48

Note: All costs are in millions of 1979 dollars excluding fee.

**COST TABLE 10-6. RL10 DERIVATIVE IIC OPERATIONS FUNDING SCHEDULE**

Study Title:	OTV Engine Study		Funding Schedule Data Form C				Date:	9/21/79
Contract No.:	NAS8-33444		Recurring (Operations)				Page:	1 of 1
Project WBS Items	FY 1	FY 2	FY 3	FY 4	FY 5	FY 6	FY 7	
Main Engine Operations (1.3)								
Flights per year								
15	12.3	11.6	10.1	9.4	7.3	5.4	2.9	
	FY 8	FY 9	FY 10	FY 11	FY 12			
15	2.7	2.7	2.6	2.6	2.6			

Note: All costs in millions of 1979 dollars include propellants cost, exclude fee



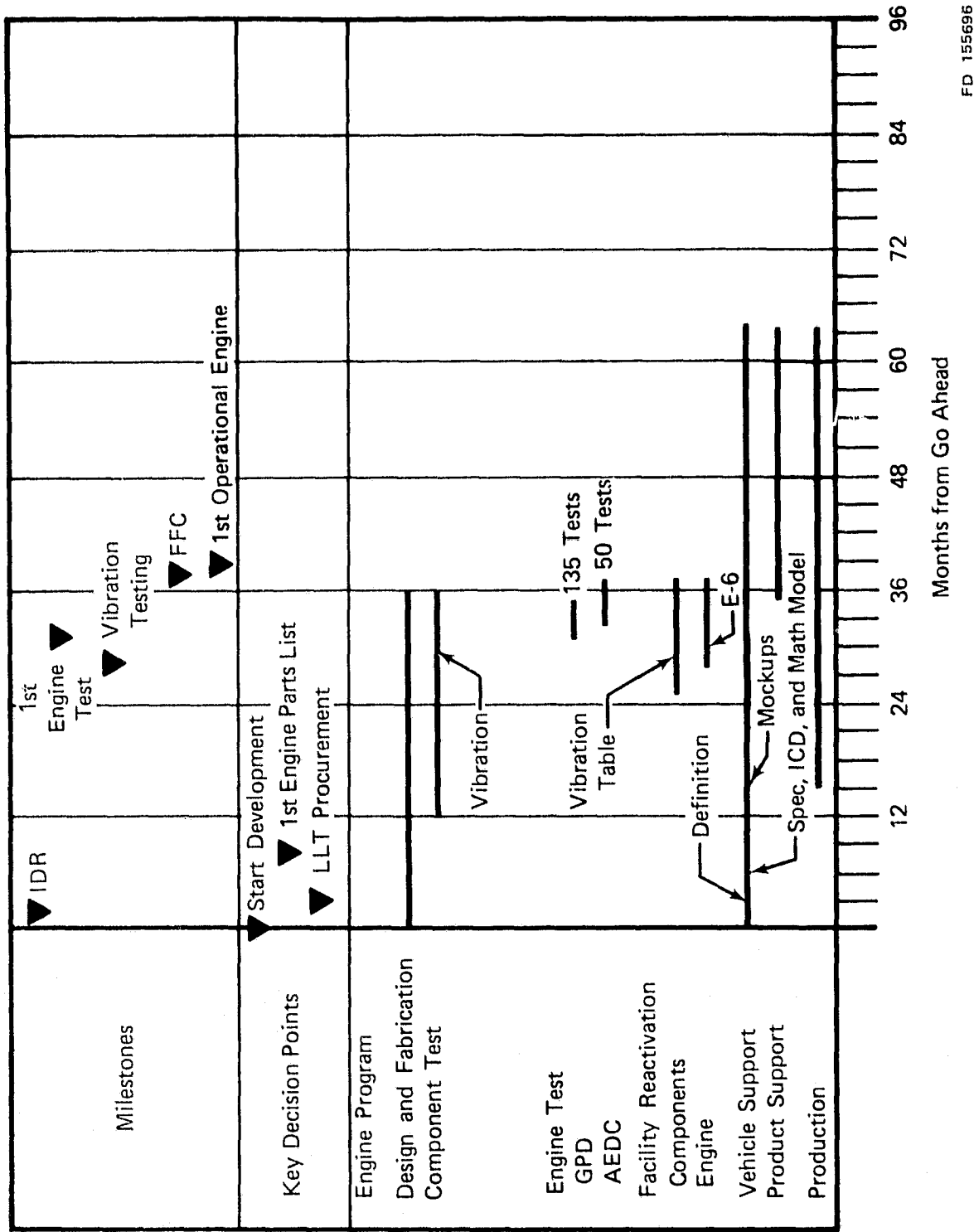
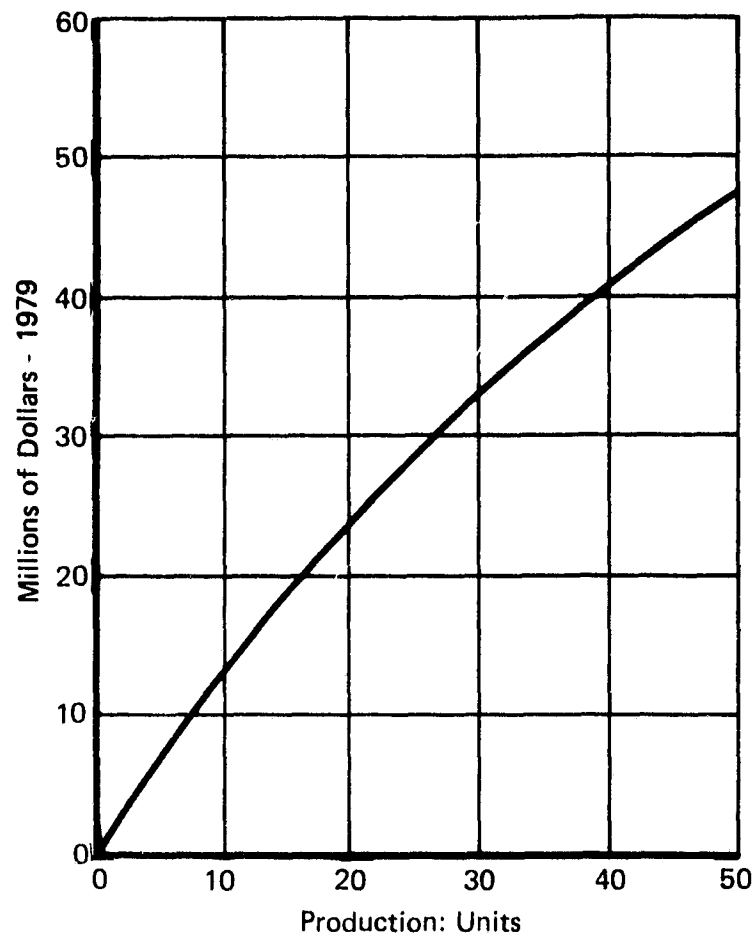


Figure 10-1. RL10 Derivative IIC Development Schedule and Major Milestones

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Figure 10-2. *RL10 Derivative IIC Engine Production Cumulative Cost Curve (Costs Include Propellants and Exclude Fee)*

## SECTION 11.0

## RL10 CATEGORY IV ENGINE PROGRAM COSTS

COST TABLE 11-1. RL10 CATEGORY IV NONRECURRING (DDT&amp;E)

Study Title:	<u>OTV Engine Study</u>	<u>Cost Data Form — A(1)</u>			Date:	<u>9/21/79</u>
Contract No.:	<u>NAS8-33444</u>				Page:	<u>1 of 1</u>
<i>Identification Number</i>	<i>WBS Identification</i>	<i>WBS Level</i>	<i>Expected Cost</i>	<i>T<sub>d</sub></i>	<i>T<sub>s</sub></i>	<i>Spread Function</i>
1.1	DDT&E	2	156.58			
1.1.1	Turbomachinery	3	23.91			
1.1.1.1	Main Fuel Pump	4	5.98			
1.1.1.2	Main Oxidizer Pump	4	4.78			
1.1.1.3	Fuel Boost Pump	4	2.39			
1.1.1.4	Oxidizer Boost Pump	4	2.39			
1.1.1.5	Assembly and Checkout	4	8.37			
1.1.2	Main Combustor Chamber	3	14.96			
1.1.2.1	Injector	4	4.49			
1.1.2.2	Chamber	4	4.49			
1.1.2.3	Upper Nozzle (Fixed)	4	1.49			
1.1.2.4	Igniter	4	1.49			
1.1.2.5	Gimbal Assembly	4	0.75			
1.1.2.6	Assembly and Checkout	4	2.25			
1.1.3	Preburner/Gas Generator	3	0.0			
1.1.4	Nozzle Assembly	3	11.31			
1.1.4.1	Lower Nozzle (Extendable)	4	6.79			
1.1.4.2	Extension/Retraction Mechanism	4	1.13			
1.1.4.3	Assembly and Checkout	4	3.39			
1.1.5	Controls	3	12.88			
1.1.5.1	Engine Controller and Electrical Harness	4	6.42			
1.1.5.2	Control Valves	4	4.39			
1.1.5.3	Instrumentation and Electrical Harness	4	0.69			
1.1.5.4	Assembly and Checkout	4	1.38			
1.1.6	Pressurization	3	1.20			
1.1.6.1	Heat Exchanger	4	0.84			
1.1.6.2	Assembly and Checkout	4	0.36			
1.1.7	Propellant Systems	3	0.30			
1.1.7.1	Feed, Fill, Vent, Abort Dump, Drain	4	0.24			
1.1.7.2	Assembly and Checkout	4	0.06			
1.1.8	Initial Tooling	3	2.83			
1.1.9	Ground Support Equipment	3	1.29			
1.1.9.1	Handling and Protective Equipment	4	0.13			
1.1.9.2	Checkout and Maintenance Equipment	4	0.78			
1.1.9.3	Assembly and Checkout	4	0.38			
1.1.10	Test	3	28.47			
1.1.10.1	Development Testing	4	10.76			
1.1.10.2	PFC Testing	4	10.66			
1.1.10.3	FFC Testing	4	7.05			
1.1.11	System Engineering and Integration	3	16.71			
1.1.11.1	Integration of DDT&E Activities	4	5.67			
1.1.11.2	Engine Assembly and Checkout	4	4.80			
1.1.11.3	Engine/Vehicle Interface	4	6.24			
1.1.12	Project Management	3	4.38			
1.1.13	Facilities and STE	3	17.69			
1.1.14	Consumables	3	20.65			

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COST TABLE 11-2. RL10 CATEGORY IV DDT&E FUNDING SCHEDULE

Study Title:	OTV Engine Study					Funding Schedule Data Form C		Date:	9/21/79
Contract No.:	NAS8-33444					Non-Recurring (DDT&E)		Page:	1 of 1
Project WBS Items	FY 1	FY 2	FY 3	FY 4	FY 5	FY 6	FY 7		
Main Engine DDT&E (1.1)	11.6	14.2	21.3	31.0	41.8	26.2	10.5		

Note: All costs in millions of 1979 dollars include propellants cost, exclude fee

COST TABLE 11-3. RL10 CATEGORY IV RECURRING (PRODUCTION)

Study Title:	<u>OTV Engine Study</u>	<u>Cost Data Form — A(2)</u>				Date:	<u>9/21/79</u>
Contract No.:	<u>NAS8-33444</u>	<u>Recurring (Production)</u>				Page:	<u>1 of 1</u>
<i>Identification</i>	<i>WBS</i>		<i>First</i>				
<i>Number</i>	<i>Identification</i>	<i>WBS</i>	<i>No. of</i>	<i>Unit</i>	<i>Expected</i>	<i>Spread</i>	<i>Learn</i>
		<i>Level</i>	<i>Units</i>	<i>Cost</i>	<i>Cost</i>	<i>Function</i>	<i>Index</i>
1.2	Production	2	50	1.76	60.14		90%
1.2.1	Main Engine	3			49.25		
1.2.1.1	Turbomachinery	4			14.12		
1.2.1.2	Combustion Devices	4			14.36		
1.2.1.3	Controls	4			13.87		
1.2.1.4	Pressurization	4			3.82		
1.2.1.5	Propellant Systems	4			1.68		
1.2.1.6	Engine Assembly	4			1.40		
1.2.2	Initial Spares	3			0.0		
1.2.3	Facility Maintenance	3			2.26		
1.2.3.1	Manufacturing & Test Facil.	4			0.0		
1.2.3.2	Sustaining Tooling	4			2.26		
1.2.3.3	GSE	4			0.0		
1.2.4	Sustaining Engineering	3			4.62		
1.2.5	Project Management	3			0.51		
1.2.6	Consumables	3			3.50		

Note: All costs are in millions of 1979 dollars excluding fee.

COST TABLE 11-4. RL10 CATEGORY IV PRODUCTION FUNDING SCHEDULE

Study Title:	OTV Engine Study	Funding Schedule Data Form C			Date:	9/21/79
Contract No.:	NAS8-33444	Recurring (Production)			Page:	1 of 1
Project WBS Items	FY 1	FY 2	FY 3	FY 4	FY 5	
Main Engine Production (1.2)	6.0	12.1	16.8	14.4	10.8	

Note: All costs in millions of 1979 dollars include propellants, exclude fee.

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COST TABLE 11-5a. RL10 CATEGORY IV RECURRING (OPERATIONS)  
15 MISSIONS/YEAR

Study Title:	<u>OTV Engine Study</u>	Cost Data Form — A(3)	Date:	<u>9/21/79</u>
Contract No.:	<u>NAS8-33444</u>	Recurring (Operations)	Page:	<u>1 of 1</u>
<i>WBS Identification</i>	<i>Identification Number</i>	<i>WBS Level</i>	<i>No. of Units</i>	<i>Expect Cost</i>
1.3	Operations	2	180	86.08
1.3.1	In-plant Support	3		27.88
1.3.2	Field Support	3		24.00
1.3.2.1	Launch Support	4		6.77
1.3.2.2	Flight Support	4		0.44
1.3.2.3	Refurbishment and Maintenance	4		10.02
1.3.2.4	Checkout	4		6.77
1.3.3	Major Engine Overhaul	3		3.29
1.3.4	Facility Maintenance	3		2.24
1.3.5	Follow-on Spares	3		5.38
1.3.6	Project Management	3		12.81
1.3.7	Consumables	3		10.48

Note: All costs are in millions of 1979 dollars excluding fee.

COST TABLE 11-5b. RL10 CATEGORY IV RECURRING (OPERATIONS)  
30 MISSIONS/YEAR

Study Title:	<u>OTV Engine Study</u>	Cost Data Form — A(3)	Date:	<u>9/21/79</u>
Contract No.:	<u>NAS8-33444</u>	Recurring (Operations)	Page:	<u>1 of 1</u>
<i>WBS Identification</i>	<i>Identification Number</i>	<i>WBS Level</i>	<i>No. of Units</i>	<i>Expect Cost</i>
1.3	Operations	2	360	94.50
1.3.1	In-plant Support	3		28.55
1.3.2	Field Support	3		27.89
1.3.2.1	Launch Support	4		7.27
1.3.2.2	Flight Support	4		0.44
1.3.2.3	Refurbishment and Maintenance	4		12.91
1.3.2.4	Checkout	4		7.27
1.3.3	Major Engine Overhaul	3		5.11
1.3.4	Facility Maintenance	3		2.24
1.3.5	Follow-on Spares	3		7.42
1.3.6	Project Management	3		12.81
1.3.7	Consumables	3		10.48

Note: All costs are in millions of 1979 dollars excluding fee.

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COST TABLE 11-5c. RL10 CATEGORY IV RECURRING (OPERATIONS)  
45 MISSIONS/YEAR

Study Title:	<u>OTV Engine Study</u>	Cost Data Form -- A(3)	Date:	<u>9/21/79</u>
Contract No.:	<u>NAS8-33444</u>	Recurring (Operations)	Page:	<u>1 of 1</u>
<i>WBS Identification</i>	<i>Identification Number</i>	<i>WBS Level</i>	<i>No. of Units</i>	<i>Expect Cost</i>
1.3	Operations	2	540	103.50
1.3.1	In-plant Support	3		29.33
1.3.2	Field Support	3		32.23
1.3.2.1	Launch Support	4		7.86
1.3.2.2	Flight Support	4		0.44
1.3.2.3	Refurbishment and Maintenance	4		16.07
1.3.2.4	Checkout	4		7.86
1.3.3	Major Engine Overhaul	3		6.91
1.3.4	Facility Maintenance	3		2.24
1.3.5	Follow-on Spares	3		9.50
1.3.6	Project Management	3		12.81
1.3.7	Consumables	3		10.48

Note: All costs are in millions of 1979 dollars excluding fee.

COST TABLE 11-6. RL10 CATEGORY IV OPERATIONS FUNDING SCHEDULE

Study Title:	<u>OTV Engine Study</u>	<u>Funding Schedule Data Form C</u>					Date:	<u>9/21/79</u>
Contract No.:	<u>NAS8-33444</u>	Recurring (Operations)					Page:	<u>1 of 1</u>
<u>Project WBS Items</u>	<u>FY 1</u>	<u>FY 2</u>	<u>FY 3</u>	<u>FY 4</u>	<u>FY 5</u>	<u>FY 6</u>	<u>FY 7</u>	
Main Engine Operations (1.3)								
<u>Flights per year</u>								
15	14.6	13.8	12.1	11.2	8.7	6.5	3.2	
30	24.6	19.8	16.1	3.8	3.8	3.8	3.8	
45	31.0	20.7	11.7	4.5	4.5	4.5	4.5	
	<u>FY 8</u>	<u>FY 9</u>	<u>FY 10</u>	<u>FY 11</u>	<u>FY 12</u>			
15	3.2	3.2	3.2	3.2	3.2			
30	3.8	3.8	3.8	3.7	3.7			
45	4.5	4.4	4.4	4.4	4.4			

Note: Costs are in 1979 millions of dollars, include propellants cost, exclude fee.

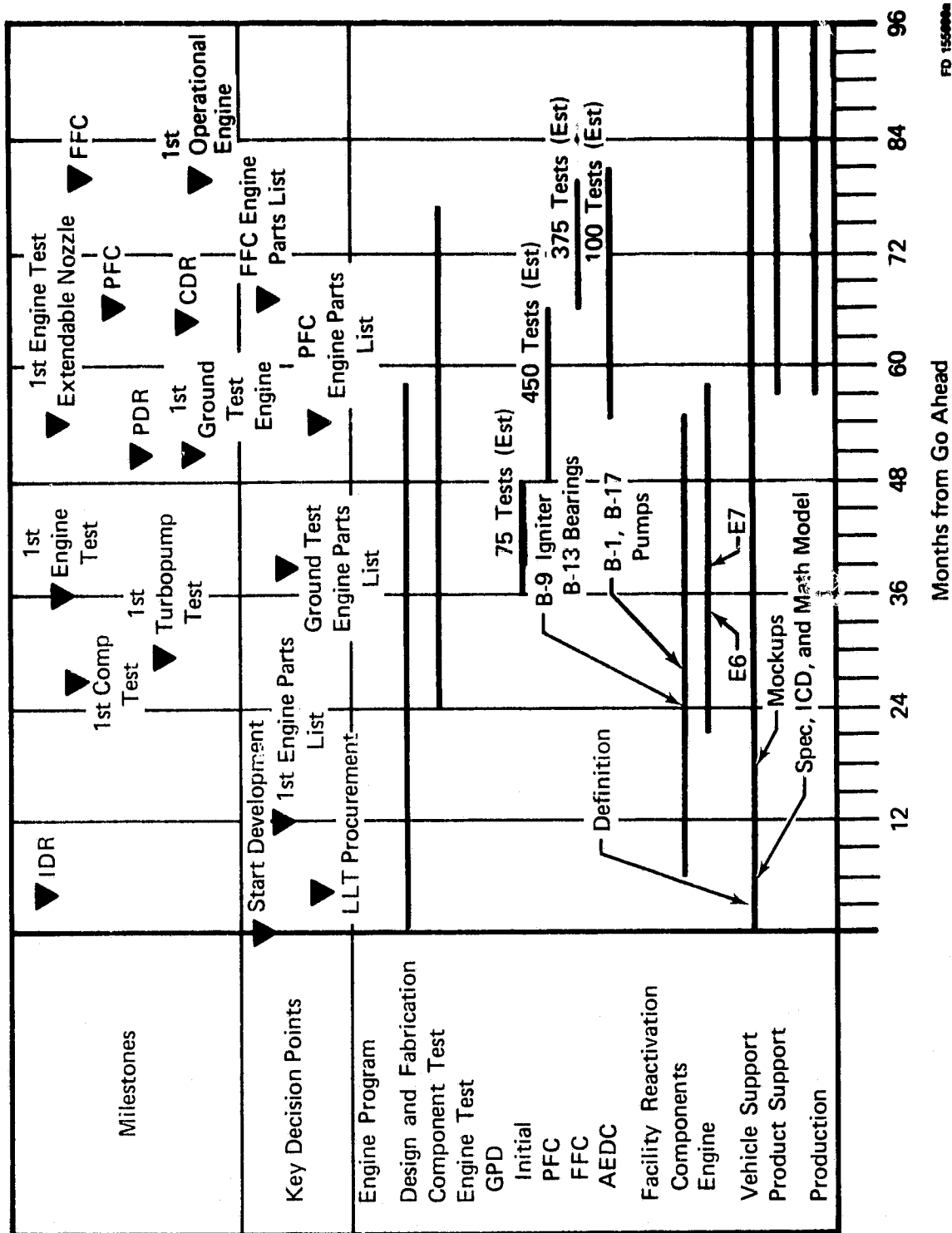
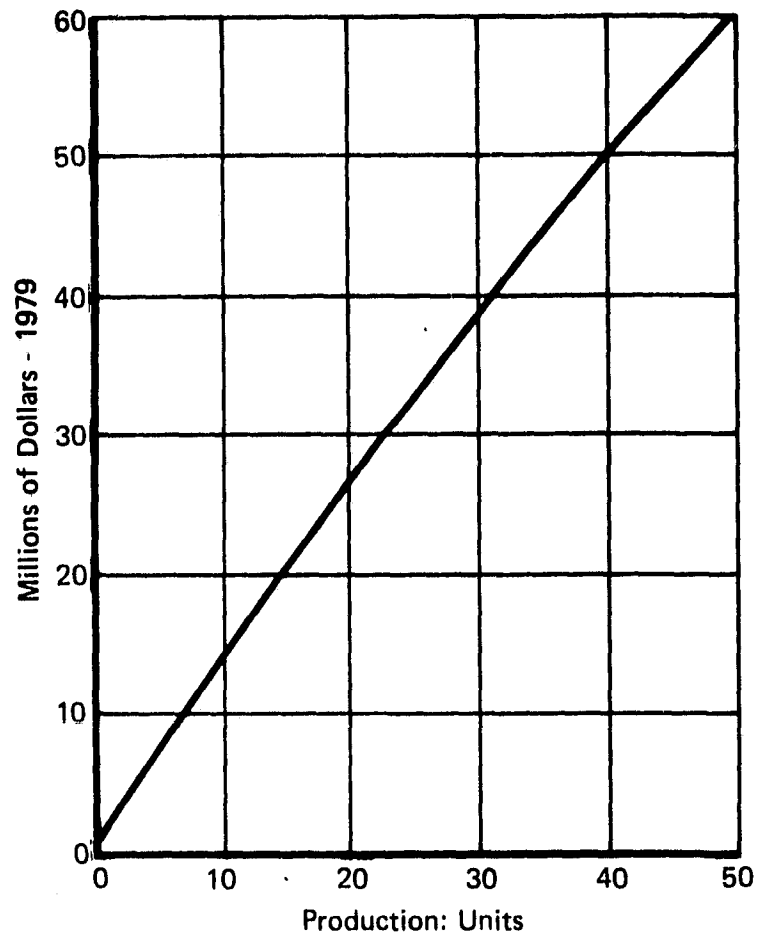


Figure 11-1. Category IV Program Schedule and Major Program Milestones

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*Figure 11-2. RL10 Category IV Engine Production Cumulative Cost Curve (Costs Include Propellants and Exclude Fee)*



## SECTION 12.0

## ADVANCED EXPANDER CYCLE ENGINE PROGRAM COSTS

COST TABLE 12-1. ADVANCED EXPANDER CYCLE NONRECURRING (DDT&amp;E)

Study Title:	OTV Engine Study	Cost Data Form — A(1)			Date:	9/21/79
Contract No.:	NAS8-33444	Non-Recurring (DDT&E)			Page:	1 of 1
<hr/>						
Identification						Spread
Number	WBS Identification	WBS Level	Expected Cost	T <sub>d</sub>	T <sub>r</sub>	Function
1.1	DDT&E	2	242.8	89	89	
1.1.1	Turbomachinery	3	47.3	30	89	
1.1.1.1	Main Fuel Pump	4	15.8	30	89	
1.1.1.2	Main Oxidizer Pump	4	9.8	30	89	
1.1.1.3	Fuel Boost Pump	4	4.0	30	89	
1.1.1.4	Oxidizer Boost Pump	4	4.0	30	89	
1.1.1.5	Assembly and Checkout	4	13.7	30	89	
1.1.2	Main Combustor Chamber	3	28.3	35	89	
1.1.2.1	Injector	4	8.3	29	89	
1.1.2.2	Chamber	4	8.3	35	89	
1.1.2.3	Upper Nozzle (Fixed)	4	3.8	35	89	
1.1.2.4	Igniter	4	1.9	24	86	
1.1.2.5	Gimbal Assembly	4	1.0	27	81	
1.1.2.6	Assembly and Checkout	4	5.0	35	89	
1.1.3	Preburner/Gas Generator	3	0.0	0	0	
1.1.4	Nozzle Assembly	3	18.1	27	56	
1.1.4.1	Lower Nozzle (Extendable)	4	11.3	27	56	
1.1.4.2	Extension/Retraction Mechanism	4	1.1	27	56	
1.1.4.3	Assembly and Checkout	4	5.7	27	56	
1.1.5	Controls	3	17.8	25	87	
1.1.5.1	Engine Controller and Electrical Harness	4	7.4	25	87	
1.1.5.2	Control Valves	4	7.4	25	87	
1.1.5.3	Instrumentation and Electrical Harness	4	0.7	25	87	
1.1.5.4	Assembly and Checkout	4	2.3	25	87	
1.1.6	Pressurization	3	3.5	24	86	
1.1.6.1	Heat Exchanger	4	2.4	24	86	
1.1.6.2	Assembly and Checkout	4	1.1	24	86	
1.1.7	Propellant Systems	3	0.5	24	76	
1.1.7.1	Feed, Fill, Vent, Abort Dump, Drain	4	0.4	24	76	
1.1.7.2	Assembly and Checkout	4	0.1	24	76	
1.1.8	Initial Tooling	3	4.7	15	51	
1.1.9	Ground Support Equipment	3	1.3	36	89	
1.1.9.1	Handling and Protective Equipment	4	0.1	36	89	
1.1.9.2	Checkout and Maintenance Equipment	4	0.8	36	89	
1.1.9.3	Assembly and Checkout	4	0.4	36	89	
1.1.10	Test	3	47.7	54	54	
1.1.10.1	Development Testing	4	17.9	12	12	
1.1.10.2	PFC Testing	4	15.4	24	24	
1.1.10.3	FFC Testing	4	13.4	18	18	
1.1.11	System Engineering and Integration	3	20.9	89	89	
1.1.11.1	Integration of DDT&E Activities	4	7.1	89	89	
1.1.11.2	Engine Assembly and Checkout	4	6.1	6	59	
1.1.11.3	Engine/Vehicle Interface	4	7.7	89	89	
1.1.12	Project Management	3	7.5	89	89	
1.1.13	Facilities and STE	3	19.4	18	51	
1.1.14	Consumables	3	25.8	24	89	

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COST TABLE 12-2. ADVANCED EXPANDER CYCLE DDT&E FUNDING SCHEDULE

Study Title:	OTV Engine Study	Funding Schedule Data Form C						Date:	9/21/79
Contract No.:	NAS8-33444	Non-Recurring (DDT&E)						Page:	1 of 1
Project WBS Items		FY 1	FY 2	FY 3	FY 4	FY 5	FY 6	FY 7	FY 8
Main Engine									
DDT&E (1.1)		15.2	21.7	28.2	35.4	47.0	37.2	34.1	24.0

Note: All cost in millions of 1979 dollars, include propellants cost, exclude fee.

COST TABLE 12-3. ADVANCED EXPANDER CYCLE RECURRING (PRODUCTION)

Study Title:	OTV Engine Study	Cost Data Form — A(2)				Date:	9/21/79
Contract No.:	NAS8-33444	Recurring (Production)				Page:	1 of 1
Identification Number	WBS Identification	WBS Level	No. of Units	First Unit Cost	Expected Cost	Spread Function	Learn Index
1.2	Production	2	50	1.87	63.5		90%
1.2.1	Main Engine	3	51		52.2		
1.2.1.1	Turbomachinery	4	51		15.1		
1.2.1.2	Combustion Devices	4	53		15.7		
1.2.1.3	Controls	4	51		13.8		
1.2.1.4	Pressurization	4	52		4.2		
1.2.1.5	Propellant Systems	4	52		1.8		
1.2.1.6	Engine Assembly	4	51		1.6		
1.2.2	Initial Spares	3	0		0.0		
1.2.3	Facility Maintenance	3	—		2.4		
1.2.3.1	Manufacturing & Test Facil.	4	—		0.0		
1.2.3.2	Sustaining Tooling	4	—		2.4		
1.2.3.3	GSE	4	—		0.0		
1.2.4	Sustaining Engineering	3	—		4.9		
1.2.5	Project Management	3	—		0.5		
1.2.6	Consumables	3	—		3.5		

Note: All costs are in millions of 1979 dollars excluding fee.

COST TABLE 12-4. ADVANCED EXPANDER CYCLE PRODUCTION FUNDING SCHEDULE

Study Title:	OTV Engine Study	Funding Schedule Data Form C				Date:	9/21/79
Contract No.:	NAS8-33444	Recurring (Production)				Page:	1 of 1
Project WBS Items		FY 1	FY 2	FY 3	FY 4	FY 5	
Main Engine		6.0	12.1	17.8	15.9	11.8	
Production (1.2)							

Note: All costs are in millions of 1979 dollars include propellants, exclude fee.

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COST TABLE 12-5a. ADVANCED EXPANDER CYCLE RECURRING (OPERATIONS)  
15 MISSIONS/YEAR

Study Title: <u>OTV Engine Study</u>		Cost Data Form — A(3)		Date: <u>9/21/79</u>
Contract No.: <u>NAS8-33444</u>		Recurring (Operations)		Page: <u>1 of 1</u>
<i>WBS Identification</i>	<i>Identification Number</i>	<i>WBS Level</i>	<i>No. of Units</i>	<i>Expect Cost</i>
1.3	Operations	2	180	86.1
1.3.1	In-plant Support	3		27.9
1.3.2	Field Support	3		24.0
1.3.2.1	Launch Support	4		6.8
1.3.2.2	Flight Support	4		0.4
1.3.2.3	Refurbishment and Maintenance	4		10.0
1.3.2.4	Checkout	4		6.8
1.3.3	Major Engine Overhaul	3		3.3
1.3.4	Facility Maintenance	3		2.2
1.3.5	Follow-on Spares	3		5.4
1.3.6	Project Management	3		12.8
1.3.7	Consumables	3		10.5

Note: All costs are in millions of 1979 dollars excluding fee.

COST TABLE 12-5b. ADVANCED EXPANDER CYCLE RECURRING (OPERATIONS)  
30 MISSIONS/YEAR

Study Title: <u>OTV Engine Study</u>		Cost Data Form — A(3)		Date: <u>9/21/79</u>
Contract No.: <u>NAS8-33444</u>		Recurring (Operations)		Page: <u>1 of 1</u>
<i>WBS Identification</i>	<i>Identification Number</i>	<i>WBS Level</i>	<i>No. of Units</i>	<i>Expect Cost</i>
1.3	Operations	2	360	94.5
1.3.1	In-plant Support	3		28.6
1.3.2	Field Support	3		27.9
1.3.2.1	Launch Support	4		7.3
1.3.2.2	Flight Support	4		0.4
1.3.2.3	Refurbishment and Maintenance	4		12.9
1.3.2.4	Checkout	4		7.3
1.3.3	Major Engine Overhaul	3		5.1
1.3.4	Facility Maintenance	3		2.2
1.3.5	Follow-on Spares	3		7.4
1.3.6	Project Management	3		12.8
1.3.7	Consumables	3		10.5

Note: All costs are in millions of 1979 dollars excluding fee.

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## COST TABLE 12-5c. ADVANCED EXPANDER CYCLE RECURRING (OPERATIONS) 45 MISSIONS/YEAR

Study Title:	OTV Engine Study	Cost Data Form	A(3)	Date:	9/21/79
Contract No.:	NAS8-33444	Recurring (Operations)		Page:	1 of 1
WBS Identification	Identification Number	WBS Level	No. of Units	Expect Cost	
1.3	Operations	2	540	103.5	
1.3.1	In-plant Support	3		29.3	
1.3.2	Field Support	3		32.2	
1.3.2.1	Launch Support	4		7.9	
1.3.2.2	Flight Support	4		0.4	
1.3.2.3	Refurbishment and Maintenance	4		16.1	
1.3.2.4	Checkout	4		7.9	
1.3.3	Major Engine Overhaul	3		6.9	
1.3.4	Facility Maintenance	3		2.2	
1.3.5	Follow-on Spares	3		9.5	
1.3.6	Project Management	3		12.8	
1.3.7	Consumables	3		10.5	

Note: All costs are in millions of 1979 dollars excluding fee.

## COST TABLE 12-6. ADVANCED EXPANDER CYCLE OPERATIONS FUNDING SCHEDULE

Study Title:	OTV Engine Study		Funding Schedule Data Form C				Date:	9/21/79
Contract No.:	NAS8-33444		Recurring (Operations)				Page:	1 of 1
Project WBS Items	FY 1	FY 2	FY 3	FY 4	FY 5	FY 6	FY 7	
Main Engine Operations (1.3)								
Flights per year								
15	14.6	13.8	12.1	11.2	8.7	6.5	3.2	
30	24.6	19.8	16.1	3.8	3.8	3.8	3.8	
45	31.0	20.7	11.7	4.5	4.5	4.5	4.5	
	FY 8	FY 9	FY 10	FY 11	FY 12			
15	3.2	3.2	3.2	3.2	3.2			
30	3.8	3.8	3.8	3.7	3.7			
45	4.5	4.4	4.4	4.4	4.4			

Note: Costs are in 1979 millions of dollars, include propellants cost, exclude fee.

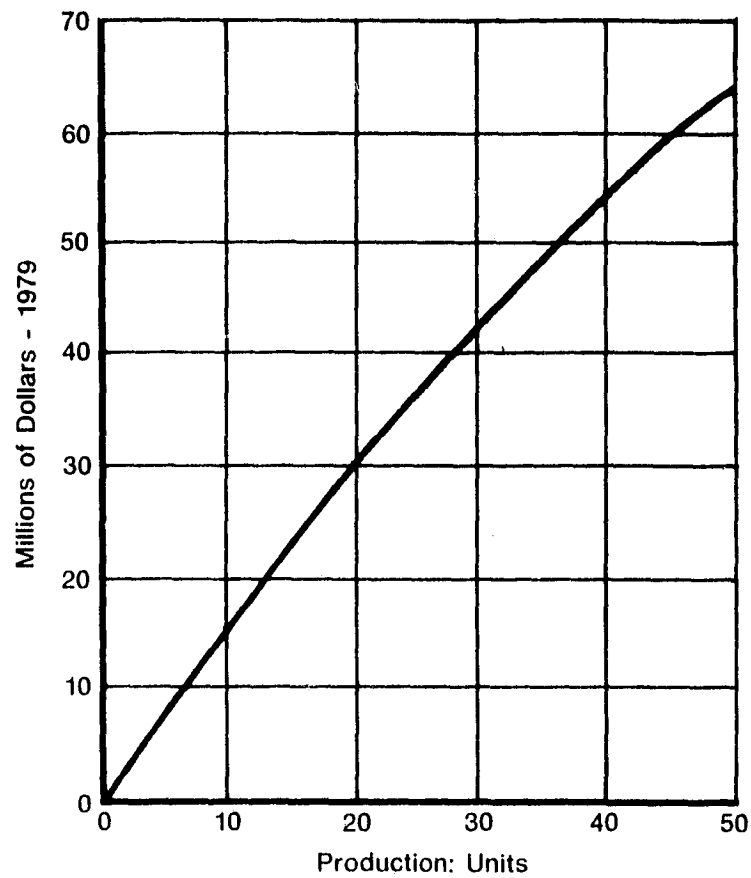


**Figure 12-1. Advanced Expander Cycle Engine Development Schedule and Major Program Milestones**

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Figure 12-2. Advanced Expander Cycle Engine Production Cumulative Cost Curve (Costs Include Propellants and Exclude Fee)